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### (54) Method and apparatus for processing animal manure

(57) The invention relates to a method for processing animal manure, in particular poultry manure, and more in particular chicken manure, characterized by the steps:

- drying the manure;
- subjecting the manure obtained in step a) to gasification, thereby yielding a combustible gas

- mixture;
- purifying the gas mixture obtained in step b);
- cracking the purified gas mixture obtained in step c), thereby yielding a mixture of at least one combustible gas, hydrogen gas and nitrogen gas; and
- cooling the gas mixture obtained in step d).

The invention also relates to an apparatus.

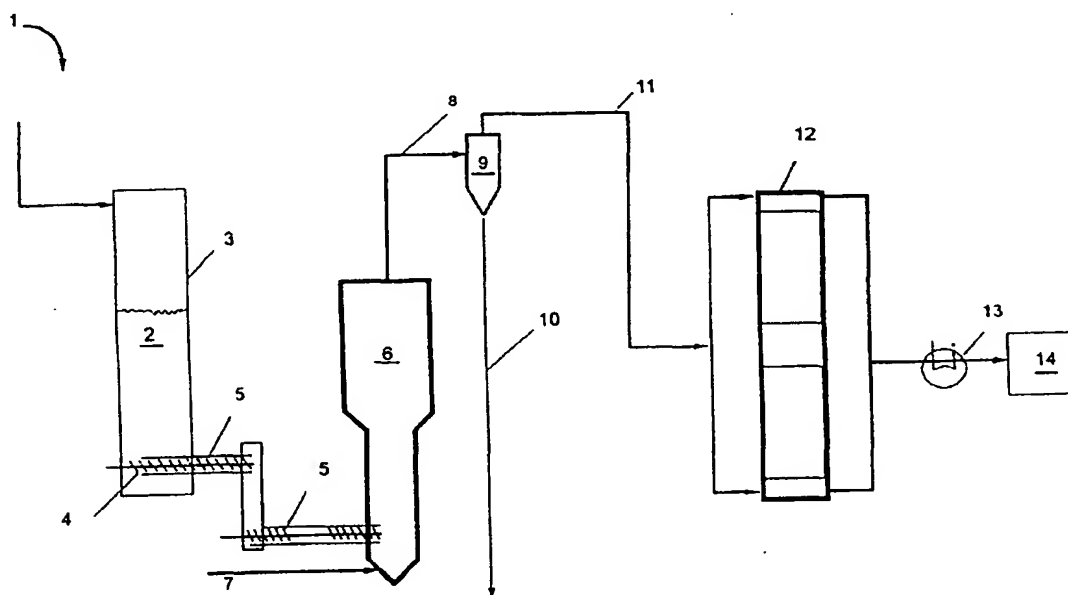


FIG. 1

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## Description

[0001] The invention relates to a method for processing animal manure, in particular poultry manure, and more in particular chicken manure.

[0002] Such a method is known in practice.

[0003] Over the past years there has been an increased interest regarding the treatment and processing of animal manure, the reasons being among others, the increasingly stringent environmental regulations imposed by the government on (poultry) farmers and an increase in costs for the disposal of the manure. However, practice has so far shown it to be impossible to process animal manure at low costs, with the result that farms (e.g. poultry farms) are burdened with considerable expenditure.

[0004] It is therefore an object of the present invention to provide a method for processing animal manure, in particular chicken manure that can be realized at relatively low costs.

[0005] It is a further object of the invention to provide such a method wherein the animal manure can be used for the generation of energy (heat and/or electricity).

[0006] These objectives are achieved by a method according to the preamble, characterized by the steps:

- a) drying the manure;
- b) subjecting the manure obtained in step a) to gasification, thereby yielding a combustible gas mixture;
- c) purifying the gas mixture obtained in step b);
- d) cracking the purified gas mixture obtained in step c), thereby yielding a mixture of at least one combustible gas, hydrogen gas and nitrogen gas; and
- e) cooling the gas mixture obtained in step d).

[0007] The gas mixture obtained by this method according to the invention may be used for the generation of energy and/or heat, for example, by feeding it to a combustion engine, such as a combined heat and power unit that drives a generator. The generator of such a total energy unit may be connected to the electricity grid. It is also possible to use the gas mixture obtained as such (via a current transmission line) in, for example a total energy unit, burner, boiler, etc., located elsewhere. The gas mixture obtained by the method according to the invention was shown to be of high quality and purity.

[0008] A further advantage of the method according to the invention is that the use of gasification makes it possible to obtain a relatively high electrical yield compared with combustion, especially on a small scale.

[0009] The method according to the invention makes it possible to gasify manure on a small scale, for example, at the (poultry) farm itself, thereby avoiding transport costs for the manure. By applying the method according to the present invention, a stock farm may be self sufficient in its electricity requirements. A possible energy surplus may be supplied to an electricity compa-

ny.

[0010] The present invention, moreover, makes it possible to process chicken manure that comprises higher concentrations of Cl, S, P and N than the usual biomass streams in an environmentally friendly manner, due to the fact that HCl, H<sub>2</sub>S and NH<sub>3</sub> (ammonia) can be effectively removed, thereby making it possible to prevent high emissions of NO<sub>x</sub> and SO<sub>x</sub>.

[0011] In accordance with the invention it is preferred for the manure in step a) to be dried to a dry solid content of at least 70%, preferably at least 80%, still more preferably 85%.

[0012] In this way the subsequent gasification will give better results. As a rule, gasification is carried out by supplying a sub-amount of air.

[0013] If desired, some litter manure may be admixed to the manure in order to raise the dry-solid content. Litter manure is a mixture of litter (wood shavings) and layer manure. Litter manure is generally drier than the manure alone (for example, from the layers), and it is usually also easier to gasify because it has a higher energy content.

[0014] According to a favourable embodiment of the method according to the invention, the gasification is a fluid bed gasification, more in particular the bubbling bed type. The gasification may be subatmospheric, atmospheric or superatmospheric.

[0015] The use of fluid bed gasification results in high gas yields. In comparison with other types of gasifiers, such as solid bed gasifiers going with the flow, or counter-flow solid bed gasifiers, and crossdraft gasifiers the fluid bed gasification of the bubbling bed type, moreover, provides better mixing and heat transfer characteristics. A bubbling bed fluid bed gasifier can be adjusted to a uniform temperature with an accuracy of a few degrees Celsius.

[0016] It is preferred for the gasification to be carried out at a temperature such as to avoid the formation of slag. The formation of slag causes the agglomeration of particles, which may results in lumps and obstruction and eventually even in the stagnation of the gasification process.

[0017] The gasification temperatures to be used in practice depend, among other things, on the composition of the manure (manure from layers, for example, has a higher ash melting point than manure from meat chickens, thus allowing it to be gasified at a higher temperature), the type of gasifier used and the bed material used in the gasifier. The wall of the gasifier may optionally be cooled, for example, with air via a valve system. The optimal gasification temperature also depends on the capacity of the gasifier used. Gasification is preferably carried out at a temperature ranging from 600 to 950°C, preferably from 700 to 800°C, still more preferably from 720 to 770°C. Above 800°C a problem may arise due to slag formation and agglomeration, this applies especially to types of manure that have a low CaO content. Below 700°C proportionately more pyrolysis

can take place, which results in an increase in tar and methane concentrations in the gas. It has been shown that for manure having a high CaO content, such as manure from layers, the above-mentioned problems the are present to a lesser extent.

[0018] The gas mixture in step c) is preferably purified in a rotating particle separator.

[0019] A rotating particle separator is compact and may be applied with favourable results at temperatures of even above 600°C. The rotating particle separator is usually operated at temperatures ranging from 400 to 650°C, preferably from 600 to 650°C under normal processing conditions. By means of the rotating particle separator it is possible to remove, among other things, fly ash and chlorine- and sulphur-comprising components (such as HCl and H<sub>2</sub>S) from the gas. The fly ash may be processed, for example, into base material for artificial fertilizer or may be used in road construction or the building industry.

[0020] If desired, the other cleaning operation may also be carried out in order to limit the emission of harmful substances such as NO<sub>x</sub>, SO<sub>x</sub>, PACs and soot as much as possible.

[0021] According to a favourable embodiment, dolomite, a sodium carbonate and/or limestone may be added to the rotating particle separator.

[0022] This effectively removes HCl and H<sub>2</sub>S from the gas.

[0023] It has been shown to be advantageous for the cracking in step d) to be carried out in a thermocatalytical tar cracker.

[0024] In a thermocatalytical tar cracker, at the surface of a (for example) Ni catalyst the remaining tars are catalytically cracked at a temperature of, for example, 900°C, and converted into smaller combustible gas components. The advantage of a thermocatalytical tar cracker is that it can be a compact device that apart from converting tar is also capable of converting ammonia (NH<sub>3</sub>). This is especially advantageous in the case of chicken manure, since a considerable amount of NH<sub>3</sub> is released during its gasification.

[0025] Instead of using a thermocatalytical tar cracker it is also possible, if desired, to use wet scrubber systems. It is in any case judicious to remove tar, since possible devices later on in the process, such as combustion engines may not be resistant to large amounts of tar in the gas.

[0026] After cracking the gas the gas is cooled, preferably to a temperature ranging from 30 to 80°C, preferably just above the dew point of the gas.

[0027] Above 80°C the capacity of a possible later combustion engine becomes increasingly limited. However, below the dew point (approximately 45°C) the formation of drops occurs, making the gas less dry.

[0028] It is preferred for the gas mixture obtained in step d) to be cooled in a heat exchanger, first with air and then with air or water (for the exact adjustment of the temperature of the gas). The air that was heated due

to its being used for cooling may advantageously be used for drying the manure in step a).

[0029] This results in a considerable saving of fossil fuel needed for drying the manure.

5 [0030] The present invention also relates to an apparatus for processing animal manure, in particular poultry manure, and more in particular chicken manure, wherein the apparatus is provided with a storage reservoir for manure, which reservoir is connected via a pipe with a gasifier, which is connected with a gas purifier having at least one outlet for solid components and a second outlet for purified gas, which second outlet is connected with a cracker in communication with a cooler, which cooler is connected with a gas reservoir.

10 [0031] The gas reservoir according to the present invention may be part of a later apparatus such as a total energy unit, may be a gas pipe connected with such a later apparatus, but may also be a storage tank that, after being at least partially filled, may be transported to another location where the gas may be utilized.

15 [0032] In the apparatus according to the present invention it is preferred for the gasifier to be a fluid bed gasifier, in particular of the bubbling bed type.

20 [0033] Using a fluid bed gasifier results in high gas yields.

25 [0034] The gas purifier is preferably a rotating particle separator.

30 [0035] By this means it is possible to remove, among other things, fly ash and chlorine- and sulphur-comprising components from the gas phase.

35 [0036] It has been shown to be advantageous for cracking to be carried out in a thermocatalytical tar cracker.

40 [0037] In this way the remaining tars and remaining ammonia are catalytically cracked and converted into combustible gas, hydrogen and nitrogen.

45 [0038] After the gas is cracked the gas is cooled, preferably in a two-stage gas cooler, first with air and subsequently with air or water. The air that was heated due to its being used for cooling may be advantageously be used for drying the manure. Of course, instead of air or water any other suitable fluid may be used.

50 [0039] The apparatus according to the present invention will now be further elucidated with reference to a drawing, wherein:

55 [0040] Figure 1 is a schematic illustration of an apparatus for processing chicken manure in accordance with the present invention.

[0041] Figure 1 shows an apparatus 1 for processing chicken manure 2. The chicken manure 2 is collected in a storage reservoir 3, which at its bottom side is provided with an outlet 4. The outlet 4 is connected via a pipe 5 to a fluid bed gasifier 6 provided with an air inlet 7.

[0042] In the embodiment shown, the pipe 5 is provided with a conveyor and metering system that employs feed screws. If desired, an additive such as dolomite, sodium carbonate and/or limestone may be supplied, for example, at one of the feed screws in the pipe 5 or at

the gasifier 6.

[0043] Via a pipe 8, the gasifier 6 is connected with a gas purifier, which in the embodiment shown is indicated by rotating particle separator 9. According to the invention, the gas purifier may consist of one device, but if desired, may comprise several devices, depending on the desired purification processes.

[0044] The rotating particle separator 9 is provided with an outlet 10 for the separation of solid components. The outlet 11 of the rotating particle separator 9 for purified gas is connected with a thermocatalytical tar cracker 12, which is in communication with a cooler 13. The cooler 13 is preferably a two-stage cooler. The cooler 13 is connected with a gas reservoir 14. This gas reservoir 14 may be, for example, a gas pipe connected with, for example, a total energy unit (not shown), boiler, burner, etc.

[0045] The method according to the present invention will now be further elucidated with reference to a non-limiting exemplary embodiment.

### Example

[0046] Chicken manure was processed by employing the apparatus of the type shown in the above-mentioned drawing.

[0047] In a time period of 8 hours, chicken manure in batches of 3 m<sup>3</sup> were dried in the storage reservoir 3 (of a round airtec manure drier; available from Farmtec B. V., at Heerde, the Netherlands) to a dry solid content of 85%. Via the feed screws in the pipe 5 the dried chicken manure underwent gastight transport to the fluid bed gasifier 6 of the bubbling bed type (bed material: SiC with dolomite), available from BTG at Enschede, the Netherlands. The chicken manure was gasified for three days at a temperature of 720°C. The combustible gas produced in this way comprised, among other things, fly ash, CO, CH<sub>4</sub>, H<sub>2</sub>, N<sub>2</sub>, CO<sub>2</sub>, C<sub>2</sub> and C<sub>3</sub> components, water vapour, tar and H<sub>2</sub>S, HCl and NH<sub>3</sub>. This mixture of combustible gas and other components was added to the rotating particle separator 9, of the E type (available from Aarding at Nunspeet, the Netherlands) and (via outlet 10) fly ash, chlorine-comprising components and sulphur-comprising components were removed. The fly ash was of a quality such as to be usable as artificial fertilizer or in the cement industry, phosphor industry, road construction or building industry.

[0048] Via the pipe 11, the remaining gas was subsequently transported to the tar cracker 12, of the catalytic reverse flow type (available from BTG at Enschede, the Netherlands), where the remaining tars and remaining ammonia were cracked catalytically (at atmospheric pressure and 900°C) and converted into, among other things, combustible gas, hydrogen and nitrogen.

[0049] The gas obtained after cracking and having a temperature of 800°C was cooled to 40°C with the aid of a two-stage gas cooler, first with air and then with water. The air that was heated (6000 m<sup>3</sup>/hour) due to its

being used for cooling was recycled for drying the manure. The warm water was buffered in a boiler.

[0050] The cooled gas was supplied to a combustion engine driving a generator. The heat that was produced was conveyed to the boiler.

[0051] Per m<sup>3</sup> imported chicken manure (dry solid content 80%), at a reactor temperature of 720°C, approximately 2-2.2 Nm<sup>3</sup> gas was obtained having a calorific value (with the exception of LHV, C<sub>2</sub> and C<sub>3</sub> components) of approximately 3.9 to 4.5 MJ/Nm<sup>3</sup>. An apparatus of a larger capacity is expected to give better results.

[0052] The present invention is not limited to the limiting embodiments described in the drawing and in the exemplary embodiment. These may be varied in numerous ways, all within the protective scope established by the claims.

### 20 Claims

1. A method for processing animal manure, in particular poultry manure, and more in particular chicken manure, **characterized by** the steps:

- a) drying the manure;
- b) subjecting the manure obtained in step a) to gasification, thereby yielding a combustible gas mixture;
- c) purifying the gas mixture obtained in step b);
- d) cracking the purified gas mixture obtained in step c), thereby yielding a mixture of at least one combustible gas, hydrogen gas and nitrogen gas; and
- e) cooling the gas mixture obtained in step d).

2. A method according to claim 1, **characterized in that** the manure in step a) is dried to a dry solid content of at least 70%, preferably at least 80%, still more preferably 85%.

3. A method according to claim 1 or 2, **characterized in that** the gasification is fluid bed gasification.

4. A method according to one of the preceding claims, **characterized in that** the gasification is carried out at a temperature such as to avoid the formation of slag.

5. A method according to claim 4, **characterized in that** gasification is preferably carried out at a temperature ranging from 600 to 950°C, preferably from 700 to 800°C, and more preferably from 720 to 770°C.

6. A method according to one of the preceding claims, **characterized in that** the gas mixture in step c) is purified in a rotating particle separator.

7. A method according to claim 6, **characterized in that** dolomite, sodium carbonate and/or limestone is added to the rotating particle separator.
8. A method according to one of the preceding claims, **characterized in that** the cracking in step d) is carried out in a thermocatalytical tar cracker. 5
9. A method according to one of the preceding claims, **characterized in that** in step e) cooling takes place to a temperature ranging from 30 to 80°C. 10
10. A method according to claim 9, **characterized in that** the gas mixture obtained in step d) is cooled in a heat exchanger, first with air and then with air or water. 15
11. A method according to claim 10, **characterized in that** the air that was heated due to its being used for cooling is used for drying the manure in step a). 20
12. An apparatus for processing animal manure, in particular poultry manure, and more in particular chicken manure, **characterized in that** the apparatus (1) is provided with a storage reservoir (3) for manure (2), which reservoir is connected via a pipe (5) with a gasifier (6), which is connected with a gas purifier (9) having at least one first outlet (10) for solid components and a second outlet (11) for purified gas, which second outlet (11) is connected with a cracker (12), which is in communication with a cooler (13), which cooler (13) is connected with a gas reservoir (14). 25 30
13. An apparatus according to claim 12, **characterized in that** the gasifier (6) is a fluid bed gasifier. 35
14. An apparatus according to claim 12 or 13, **characterized in that** the gas purifier (9) is a rotating particle separator. 40
15. An apparatus according to one of the claims 12-14, **characterized in that** the cracker (12) is a thermocatalytical tar cracker. 45
16. An apparatus according to one of the claims 12-15, **characterized in that** the cooler (13) is a two-stage cooler. 50

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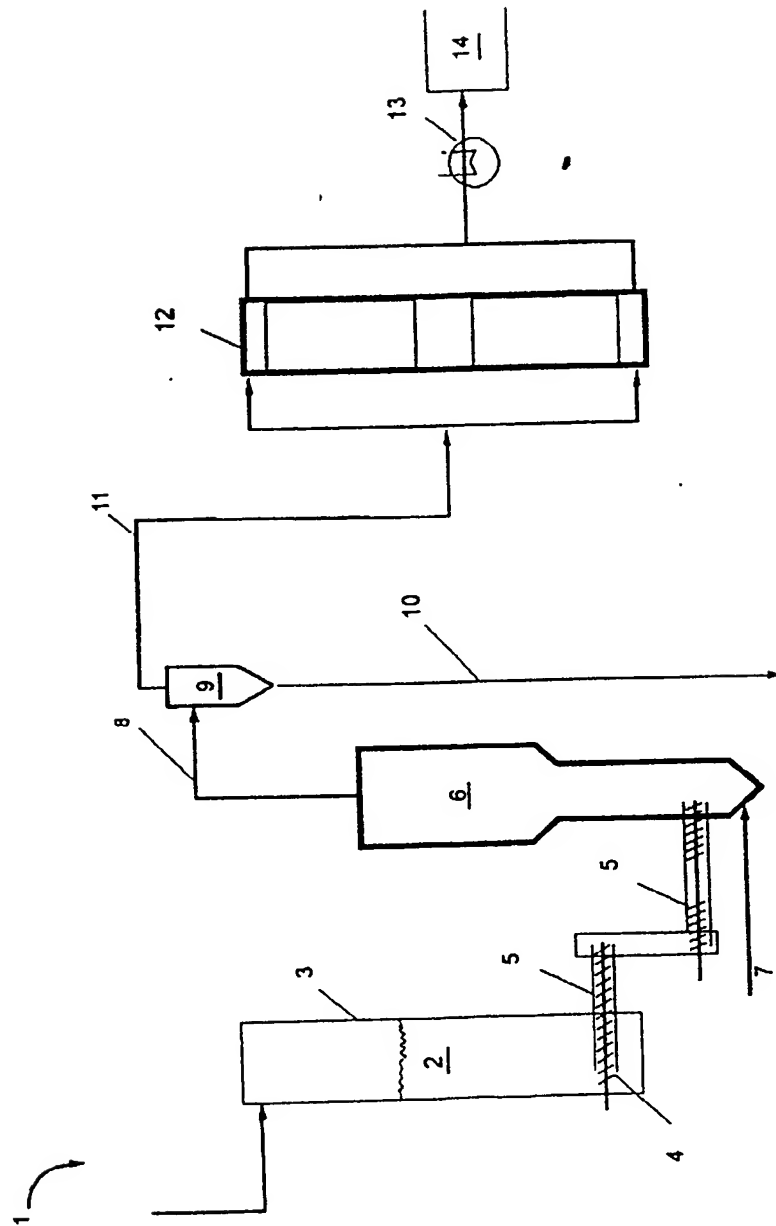


FIG. 1



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# EUROPEAN SEARCH REPORT

Application Number  
EP 01 20 3191

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.CI.7)
A	US 4 497 637 A (PURDY KENNETH R ET AL) 5 February 1985 (1985-02-05) * claims 1,2,4,9,10 *	1,2,4,5, 9,12,13	C10J3/54
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			TECHNICAL FIELDS SEARCHED (Int.CI.7)
			C10J
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>30 November 2001</b>	Examiner <b>De Herdt, O</b>
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**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 01 20 3191

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30-11-2001

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